Narrowband Multi-channel Data Radio Modem

LinkWiser™-S400M Rev. 2.1

Technical data & Users' Manual

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1. REVISION HISTORY

REVISION	SIGNED	DATE	DESCRIPTION
2.0	JN Lee	15/10/2010	Document created
2.14	JSM, KYC	21/9/2011	Sleep current adjusted

2. PRODUCT OVERVIEW

LinkWiser™-S400M Rev. 2.1

Narrowband multi-channel data radio modem

LinkWiser™-S400M Rev. 2.1 series support a narrowband, 12.5KHz channel spacing and an exceptional receiver sensitivity, -113dBm and is a complete wire-replacement solution (RS-232C, RS-485) with multi-channel operation that enables easy to connect between DTE and LinkWiser™-S400M Rev. 2.1 without additional interface circuits. It is all that just plug into power and connect it to DTE.

LinkWiser™-S400M Rev. 2.1 supports point-to-point, point-to-multi, multi-drop and repeater function in compliances with most of wire-line based networking solutions such as Profibus, Modbus, Pelco-D, Pelco-P, etc. and realizes 0% PER (Packet Error Rate) in 800 meters (about half mile) - LOS (Line of Sight), 14bytes @ 1000 times, 0dBi antenna, 4.8kbps air rate - at max. 10mW (+10dBm) output power.

LinkWiser™-S400M Rev. 2.1 is ideally suitable where higher reliability and performance is required.

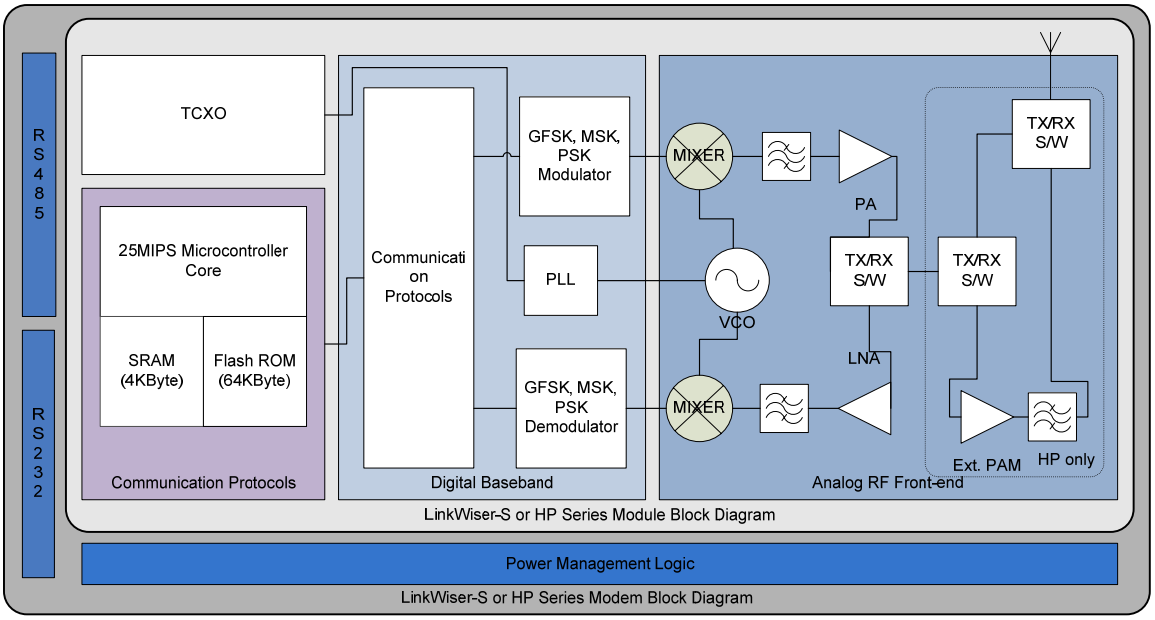
LinkWiser™-S400M Rev. 2.1 is ideally suitable with South Korean KCC & Japanese ARIB regulations. And it supports 400~470MHz frequency band at 12.5KHz of narrowband operation.

LinkWiser™-S400M Rev. 2.1 is approved by South Korean Authority in conjunction with LARN2-IO2S424.7125/424.9500TR0.01F1D22220 (데이터전송용, 424MHz, 20ch), 447.8625/447.9875TR0.01F1D11 (데이타전송용, 447MHz, 11ch) and LARN3-IO447.2625/447.5625TR0.01F1D25 (안전시스템용, 447MHz, 25ch). And KCC ID is "CE3-LinkWiserS400M.

Items	LW-S400M	**LW-S400M Rev. 2**
RF performance	Less robust	**Robust**
Current consumption	Tx: 80mA (10dBm) Rx: 80mA Sleep: 30mA (deep sleep)	**Tx: 63mA (10dBm)** **Rx: 53mA (ext. LNA off)** **65mA (ext. LNA active)** **Sleep: 23mA (deep sleep)** **23mA (RTC active)**
External LNA	No	**Yes**

2-1. PICTURE

3. BLOCK DIAGRAM



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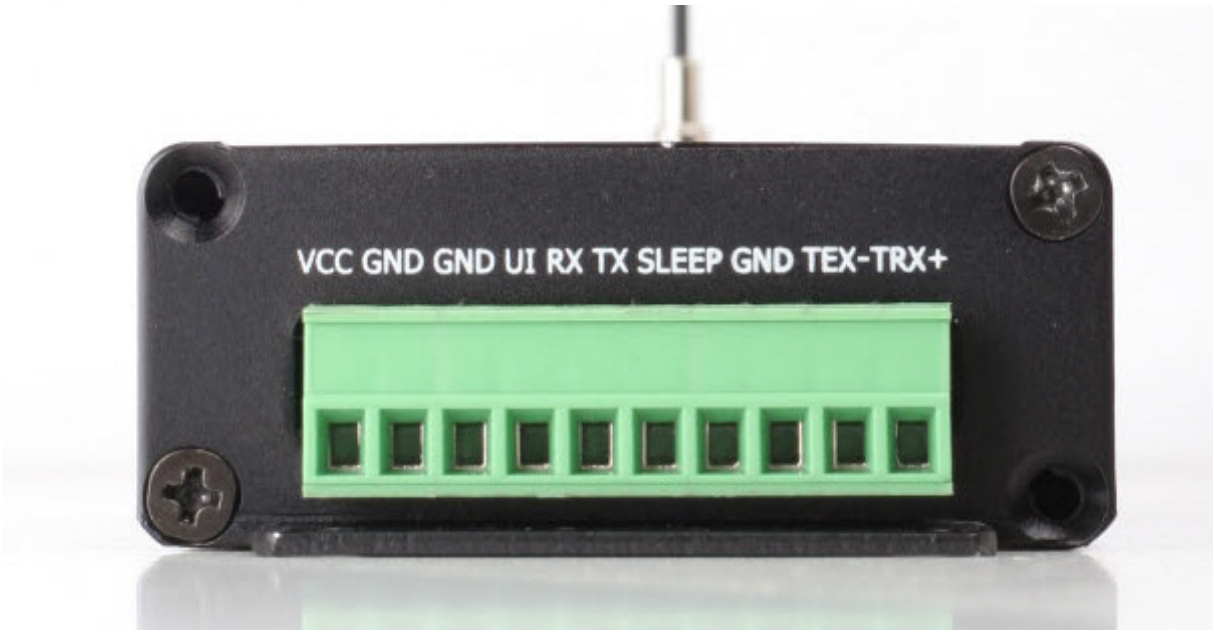
4. FEATURES

- ✓ simple 10 pin interface
- ✓ 2 different mode (Transparent, Address) programmable
- ✓ Repeater mode support
- ✓ Easy to use AT command set
- ✓ A few clicks only for configuration (No RF knowledge requirement)
- ✓ Low power consumption for battery operation
- ✓ Robust anti-interference HDLC protocol
- ✓ 12.5KHz of narrowband
- ✓ 424, 447MHz (Korea)
- ✓ Exceptional sensitivity (-113dBm @ 4.8kbps)
- ✓ Long distance communication: Up to 800meters in line of sight.
- ✓ Operating temperature: -30 ~ 80°C
- ✓ Programmable COM baud rate (1.2 ~ 38.4kbps)
- ✓ Compliance with the registration regulation of the government
- ✓ Low cost, prompt delivery and no limit to the quantity of order

5. APPLICATIONS

- ✓ Handheld terminals
- ✓ Heavy vehicle/machine remote controls
- ✓ EPOS equipment, barcode scanners
- ✓ Data loggers
- ✓ Industrial telemetry and telecommand
- ✓ In-building environmental monitoring and control
- ✓ High-end security and fire alarms
- ✓ Vehicle data up/download
- ✓ AMR
- ✓ Wireless home networking

6. PIN DESCRIPTIONS



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Item no	PIN	Description Level Connected to the terminal	DTE (User terminal)	Remarks
1	VCC	Power input 6.5VDC ~ 24VDC		
2	GND	Power supply/Ground	DGND/AGND	
3	GND	Power supply/Ground	DGND/AGND	
4	U/I	User Interface		
5	RX_D	Serial data receiving end	CMOS: TX_D	RS232C
6	TX_D	Serial data transmitting end	CMOS: RX_D	RS232C
7	Sleep	Sleep control (input) end		2.8V (low Active)
8	GND	Power supply/Ground	DGND/AGND	
9	TRX-	Serial data		RS485
10	TRX+	Serial data		RS485

7. WIRING DIAGRAM

TO BE UPDATED

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8. MAXIMUM RATINGS

Operating temperature	-30°C to +80°C
Storage temperature	-40°C to +85°C
LinkWiser™-S400M Rev. 2.1	
VCC (pin 1, 2)	6.5VDC ~24VDC

9. SPECIFICATIONS

Parameter	Rating	Conditions
General characteristics		
Communication method	Half-duplex	
Oscillation type	PLL Controlled VCO	
Operating frequency range	400~470MHz	*see frequency table at 12-4-1
Channel step	12.5KHz	
OBW (Occupied Band Width)	<8.5KHz	@ 12.5KHz w 4.8kbps
Frequency stability	+/- 2.0 ppm	-30 to +80 °C
Air data rate	4.8kbps	@ GFSK w 12.5KHz
PLL LOCK TIME (free to RX)	<50us	
(RX to TX)	<80us	
Operating voltage range	3.6V +/- 10%	
Dimensions	See the below dimension	
Transmitter part		
RF output power (E.R.P)	+10dBm +/- 1 dBm	Max. 13dBm available on request
TX S/N	-40 dBc	
Spurious emission	-40 dBc	< 1 GHz
	-55 dBc	> 1 GHz
Adjacent channel leakage power	-37 dBc	
Consumption current	63 mA	@ +10dBm of Tx output power
Receiver part		
Input sensitivity at Bit error rate	-113 dBm	@ 4.8kbps, w 12.5Khz channel step
Distortion	-30 dB	
Spurious emission	-40 dBc	
Consumption current	Less than 53 mA Less than 65 mA	**(ext. LNA off) - default** **(ext. LNA active)**
	Less than 23 mA	Sleep Mode* Sleep Mode @ RTC active*

Note: * the radio section is disabling in the sleep mode.

10. DIMENSION

120 (H) x 60 (W) x 27 (D) mm

11. INTEGRATION GUIDE

LinkWiser™-S400M Rev. 2.1 owns a voltage regulator which always supplies 2.8VDC to the entire circuit except POWER APLIFIER that receives 6.5VDC ~ 24VDC of input voltage directly. And this is for stable operation & performance especially in RF front end side. Nevertheless, qualified external power supply is necessary, which must be in 6.5VDC ~ 24VDC with more than 40dB of ripple rejection by an external voltage regulator.

11-1. COMMUNICATION RANGE

The communication range is a key factor to be considered. And there are some considerable variants to get preferred communication distances.

- ✓ Type and location of antennas in use
- ✓ Type of terrain and degree of obstruction of the link path
- ✓ Sources of interference affecting the receiver
- ✓ "Dead" spots caused by signal reflections from nearby conductive objects
- ✓ Data rate and degree of filtering employed

However, our agency approved antennas must be applied to inherit our modular approval.

11-2. ANTENNA MATCHING

Most important for effective data transmission is selection of a good antenna, and RF grounding, both for the transmitter and the receiver. Without a good antenna it is impossible to transmit data over a long distance.
The LinkWiser™-S400M Rev. 2.1 has the SMA connector basically. And, it doesn't require additional antenna matching if you purchase Cellution's antennas.

In most cases the following basic rules will help you.

- ✓ Connect an antenna with 50-Ohm impedance.
- ✓ Place the antenna vertically, straight up or down from the transmitter and receiver module.
- ✓ Do not cover the antenna with metal parts.

The connection of the metal surface of the receiver case to a larger metal part (ground plane) will increase radiation efficiency. Such metal parts should not be placed near the antenna.
The human body can have a similar effect to metal objects. Pocket receivers should be held in the hand and held in a position away from the body.
Best range is achieved if the transmitter and receiver antenna are in direct line of sight. Any object in between the transmitter and receiver antenna, and metallic objects in particular, will decrease the range.

The transmission is influenced by reflections of the transmitter signal on metallic surfaces and building. There is possibility that data errors will occur due to overlapping of the direct and reflected signals.

11-3. MODULE MODIFICATION

The module must not be physically altered in any way.

11-4. END PRODUCT LABELING REQUIREMENTS

Pursuant to KCC (South Korea) or ARIB (Japan) regulations, the end product must be type approved. The LinkWiser-S400M, a complete modem (+6.5VDC to +36VDC) that is type approved by South Korean KCC.

Please contact support@cellution.co.kr for more details.

12. CONFIGURATION

This section describes the configuration and test commands supported by the radio module. In most cases, once the configuration is set it will not need to be changed. Configuration is performed using a serial terminal, or appropriate communication application.
All commands and command values accepted by the radio module are described in this section; any entries other than those listed here results in an invalid command or argument error message.
The first step to configuring the Radio Module is to put it in Configuration Mode.

12-1 Entering Configuration Mode

A series of three consecutively typed characters, called an escape sequence, forces the radio module to exit data transfer mode and enter the module configuration mode. While in Configuration Mode, you can communicate directly with the radio module using a number of specific commands to configure and test the radio module.
The escape sequence is factory set to '+++' (No carriage return key is followed). A pause length of which is called the escape guard time (about 1s) must be completed both before and after when escape sequence is entered. These three '+' characters must not be sent as one continued frame. The delay between 2 characters must be between 10ms~1s for the ('+++') sequence. This prevents the radio module from interpreting the escape sequence as data and the vice versa. The guard time must also be met when the Radio Module is initially powered up.
Configuration changes are stored permanently in non-volatile memory within the Radio Module. Exiting Configuration Mode and returning back to data transfer mode is accomplished by typing "ATO" at the command prompt. This will force a soft reset of the Radio Module resulting in any configuration changes taking effect.

12-1-1 Command Format

LinkWiser™ module's parameters are set through the use of AT type commands sent on the serial link. 'AT' commands complies with Hayes protocol used in PSTN module standards. This 'AT' protocol is used to configure the module parameters, based on the following principles:

A data frame always begins with the two ASCII 'AT' characters, standing for 'ATtention', Commands are coded over one or several characters and may include additional data.
A given command always ends up with a < CR> Carriage Return.

AT	COMMAND	ADDITIONAL DATA	<CR>

Note: The delay between 2 characters of the same command must be less than 30 seconds.
All alphabetical characters typed in configuration command mode are converted to upper case before being interpreted by the configurator. Thus commands can be typed using either upper or lower case.
Despite its similarity to standard telecommunication module, it remains a radio link module and is consequently fitted with some particular and specific 'AT' commands proper to radio transmission (I.e. communication channel, radio rate...).

12-1-2 Configuration Commands in details

+++ Configuration mode Command	Configuration Mode Activation '+++' Command gives an instant access to the module's parameters configuration mode (AT mode). '+++' Command should be entered one by one. The time between two '+' must be between 10ms ~1s. Answer: > Description

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ATO	Communication mode activation 'ATO' command gives an instant access to the module's Operating mode. 'ATO' command is used to get out of Configuration Mode. Answer: Good Bye!
AT/V Register Handling Command	'AT/V' command displays the module's firmware version Ex) AT/V<CR> 'S424V1.0' // LinkWiser-S, 424MHz, V1.0 'HP915V2.0 // LinkWiser-HP, 915MHz, V2.0
AT/L	'AT/L' command displays a dynamic and clear status of all relevant registers of the module with the following categories: Serial link, Radio, Operation Mode, Network (for consumers)
AT+I	Factory default Set all registers' values to factory default ones

12-1-3 Registers Description

The parameters to be configured via Configuration mode are stored in module's EEPROM's registers, called S registers. Those registers are always listed as follows:
The standard registers and their use are shown in the next table.

Access	Registers	Name	Description
R/W	ATS102 Serial FIFO Time Out	Serial Link Time Out	Indicates the value of the time-out on the serial link (in Byte). Ex): a value '3' means a 3 bytes or milli sec. time out time. This is used: when the serial FIFO is not full, after this time out, the data in the FIFO will be sent out via RF link. Value Range: 3~255, Default: 5
R/W	ATS103 *	Sleep Mode Control *	Sleep Mode Control: 0 – Disabled (Default), module always active 1 – Enabled If S103=1, the module will be controlled by I/O1 I/O1 = 0: Sleep Mode(power down mode) I/O1 =1: active
R/W	ATS104	Serial Baud Rate	Indicates the serial baud rate with DTE: '0': 1200 bps '1': 2400 bps '2': 4800 bps '3': 9600 bps (default) '4': 19200 bps '5': 38400 bps
R/W	ATS120	Network ID	Network ID in 2 Bytes. Ex).: ATS120=192.168 will set the network ID to 192.168
R/W	ATS121	Group ID	Group ID. All and only devices with the same group id (together with the network id) will be linkable.
R/W	ATS122	Device ID	Device ID Value Range: 1~255, Default: 1
R/W	ATS130	Node Type	Node Type '0': Normal node (not intent to route a message) '1': Repeater node (This is a repeater, and will route any message it received)
R/W	S131	Via Repeater Link	Via Repeater Link Control '0' : Disabled

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			'1': Enabled Ex): Assuming that S130 = '0' & S131 = '1', the TX data will automatically routed to & by the repeater(address defined by S132)
R/W	ATS132	Repeater Address	Repeater Address Ex): Assuming that S130='1', this register will set the desired repeater's address. All data will be sent to the repeater node first, and that repeater will automatically route the data to the preset destination.

NOTE:
***The SLEEP mode realizes less than 23mA current consumption. In this case, entire RF section is disabling where baseband is active. The sleep mode w RTC (Real Time Clock) is available on request for repetitive wake-up operation.**

12-2 Transparent Mode

The transparent mode is the default communication mode, based on null-module cable emulation. Basically, the module in the transparent mode supports a complete wire replacement for RS-485, RS-232 or RS-422 cable by half-duplex communication method.
This mode can be used as Point to Point or Point to Multi-point with all the modules receiving the messages sent by any module. DTE should hold I.D recognition & generation algorithm in the USER DATA.

12-2-1 Operation

Radio modules in transparent mode behave like wired serial links. Therefore, radio modules automatically transmit every serial data received on their radio link, and also transmit all radio information received on their serial link. The transparent mode can be operated for both point-to-point and multipoint links.
The data flow control may be carried out by software applications used by various protocols such as ProfiBus, ModBus, etc…
Consequently, the latency time is reduced to its minimum as the module no needs wait to check the acknowledgment byte.
Any unit, with the same network ID and group ID, configured in transparent mode will receive every radio data flowing on the same communication channel, i.e. on the same frequency.

12-2-2 Examples of configuration with AT commands for transparent mode

User +++ // Switch to Configuration mode
Module >
User ATS120=192.168<CR> // Set network ID to 192.168
Module >
User ATS121=120<CR> // set group id to 120
Module >
User ATS122=10<CR> // set device id to 10
Module >
User ATO<CR> // exit from the configuration mode
Module Good Bye!

User AT+ADDR=0 // set the operation mode to transparent mode
User DATA

12-3 Address Mode

The addressed mode is similar to a multipoint mode. All modules can communicate with each other by addressing each frame to one of them.

12-3-1 Operation

Addressed mode's purpose is to offer an optimal radio link performance providing the multipoint access of the transparent mode.
Compared to the transparent mode, the addressed mode therefore includes the additional feature to address each data frame to a specific module.

12-3-2 Examples of configuration with AT commands for address mode

User +++ // Switch to Configuration mode
Module >
User ATS120=192.168<CR> // Set network ID to 192.168
Module >
User ATS121=10<CR> // set group id to 10
Module >
User ATS122=10<CR> // set device id to 10
Module >
User ATO<CR> // exit from the configuration mode
Module Good Bye!

*****To send data to specific I.D of same group, same network & same frequency, you have to set AT+ADDR command before sending user data.**

User AT+ADDR=16 // set the operation mode to address mode & the destination I.D is 16.
User DATA

12-4 Extended AT Command Set
This section describes the list of the extended at command set that is working on normal working mode, not on '+++' Configuration mode.

12-4-1 CH R/W

Reading: 'AT+FREQ?'
Answer: channel: 1
Freq: 424.7125MHz

Writing: AT+FREQ=5
Answer: >

Frequency channel table in 424MHz band

Frequency (MHz)	Value
424.7125	1
424.7250	2
424.7375	3
424.7500	4
424.7625	5
424.7750	6
424.7875	7
424.8000	8
424.8125	9
424.8250	10
424.8375	11
424.8500	12

424.8625	13
424.8750	14
424.8875	15
424.9000	16
424.9125	17
424.9250	18
424.9375	19
424.9500	20

Note:
Listen-Before-Talk (LBT) must be applied. Tx is allowed in case of less than -90dBm of RSSI level only in all channels. And the continuous Tx is limited to 40 seconds only.

Frequency channel table in 447MHz A band

Frequency (MHz)	Value
447.2625	21
447.2750	22
447.2875	23
447.3000	24
447.3125	25
447.3250	26
447.3375	27
447.3500	28
447.3625	29
447.3750	30
447.3875	31
447.4000	32
447.4125	33
447.4250	34
447.4375	35
447.4500	36
447.4625	37
447.4750	38
447.4875	39
447.5000	40
447.5125	41
447.5250	42
447.5375	43
447.5500	44
447.5625	45

Frequency channel table in 447MHz B band

Frequency (MHz)	Value
447.8625	46
447.8750	47
447.8875	48
447.9000	49
447.9125	50
447.9250	51
447.9375	52
447.9500	53
447.9625	54
447.9750	55
447.9875	56

12-4-2 Tx power control

Reading: Reading: 'AT+P?'
Answer: TxPower: 8
10dBm

Writing: 'AT+P=8' // Set the Tx power at 8th level
Answer: >

Description: Power of the Radio

Value	Tx power (dBm)
8	< 10dBm
7	< 9dBm
6	< 7.9dBm
5	< 6.3dBm
4	< 4.4dBm
3	< 2dBm
2	< -1.3dBm
1	< -7.0dBm
0	< -40dBm

12-4-3 RSSI level

Reading: 'AT+CSQ?'
Answer: 'n'

Description: 'n' is a realistic RSSI level in the unit of 'dBm'. (-60~-120)

Caution: One time RSSI level reading may not be correct due to circumstances. Thus, more than three times of RSSI level readings are recommended.

12-4-4 Destination address setting

Reading: 'AT+ADDR?'
Answer: destination ID: 'n' // n ranges 0~255

Writing: 'AT+ADDR=n'

Description: ADDR means a destination ID, if it is set '0' in the ADDR, the radio enters into the Transparent mode. while it is set '1~255' in the ADDR, the radio enters into the Address mode and delivers data to the preset destination ID of node only.

12-5 Timing Chart

12-5-1 Maximum Packet Size

The LinkWiser accepts **256bytes of packet size of USER DATA only** as its one time maximum FIFO (First-In-First-Out) is 256bytes. If your packet size (USER DATA) exceeds over 256bytes, then you have to split them into several appropriate size of packets with considering the below timing chart & air rate. And also you have to put some delay between that divided packet and the packet with considering the below timing chart & air rate in order to complete successful transmission.

12-5-2 Timing Chart Overview

Figure1 shows a typical system block diagram comprising hosts (DTE user's application) connected to LinkWiser. Host(A) will be sending and Host(B) will be receiving and processing this data.

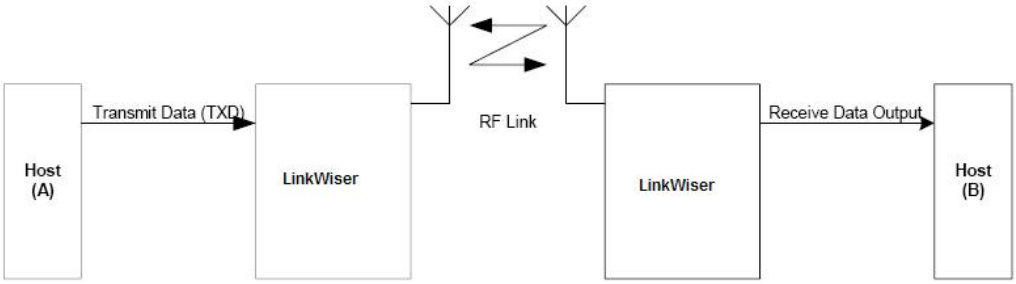


Figure1 Typical System Block Diagram

Data is sent and received in standard 'RS232' serial format and there is no restriction on characters that may be sent.

If you configure "Serial Link Time Out" value more than one byte interval, the data flow look like Figure2, but if you configure "Serial Link Time Out" value less than one byte interval, the data flow looks like Figure3.

We recommend Figure2 configuration rather than Figure3 for more robust RF transmission. Configuring "Serial Link Time Out" like Figure3 enables to split the packet into several frames and re-packetize that frame with adding pre-defined preambles, headers and post-ambles automatically. Thus, this case makes more overhead on RF section rather than original USER DATA eventually.

A: TX UART Timing | B: AIR RATE Timing | C: RX UART Timing

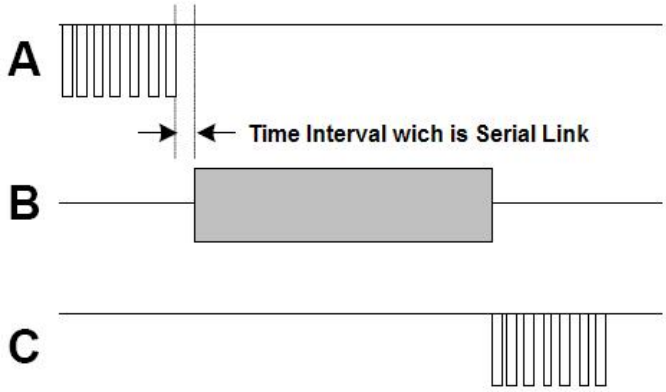


Figure2: Serial Link Time Out is more than 1byte time Interval

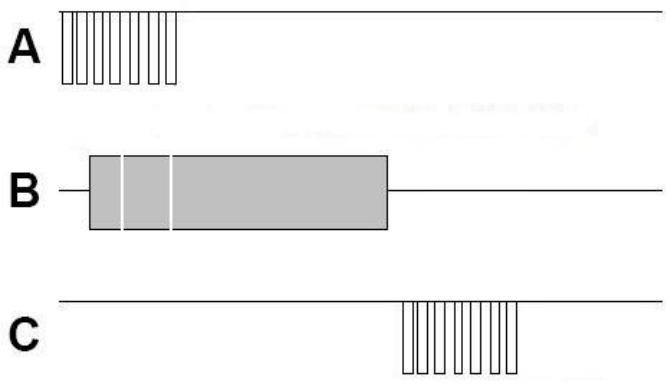


Figure3: Serial Link Time Out is less than 1byte time Interval

12-5-3 UART Timing in Tx

You MUST configure the Serial Link Time Out value depending on DEPENDING ON YOUR SERIAL BAUD RRATE.

EX) If your serial baud rate is 9600bps, we recommend over 1ms of the Serial Link Time Out value. Thus, you can get a result same as the above Figure2.
9600bits/second = 9600bps, then 960bytes/second because start bit & stop bit should be added.
1byte time interval in the UART section at 9600bps is around 1.042ms. And data processing time from the LinkWiser is required. That is less than around 0.8ms. Thus, over 2ms of the Serial Link Time Out value is recommended.

A (ms) > = 1,000 (1 sec = 1,000 milli sec.) / Serial Baud Rate (bps) / 10 (start bit + 8 user bits + stop bit) + 0.8ms

If we apply the calculation to various UART baud rates,
Over 9ms of the Serial Link Time Out value is recommended in 1200bps
Over 4ms of the Serial Link Time Out value is recommended in 2400bps
Over 3ms of the Serial Link Time Out value is recommended in 4800bps
Over 2ms of the Serial Link Time Out value is recommended in 9600bps
Over 1ms of the Serial Link Time Out value is recommended in 19200bps

12-5-4 Air Timing

Apart from the above Serial Link Time Out value, **developers & integrators MUST recognize & calculate how long the LinkWiser occupy a frequency to complete transmitting the USER DATA from host(s).**

First of all, you have to understand that the LinkWiser doesn't send the USER DATA as is. The LinkWiser re-packetizes the USER DATA to transmit into the air.

Normally **51 bytes of packet overhead in case of transparent networking topology & 53 bytes of packet overhead in case of address networking topology** are required to add on USER DATA.

Thus, the calculation is as follows;

1 Byte Time Interval (B) = 1,000 (1 sec = 1,000 milli sec.) / AIR RATE (bps) / 8 (8 bits = 1 byte)
Ex) 1.67ms = 1,000 / 4,800bps / 8

But, LinkWiser adds some headers and footers on existing USER DATA. Thus, [USER DATA (bytes) + 51 (Transparent) or 53 (Address)] + 2ms (Margin) = Total Air Time (ms)

Ex) If air rate is 4800bps & USER DATA is 50 bytes in transparent mode,
1.67 (B) * [50 (USER DATA) + 51 (Overhead, Transparent)] + 2 (Margin) = around 170.67ms

12-5-5 UART Timing in Rx

There is no time interval.

12-5-6 Conclusion (TOTAL TIME CONSUMING)

C (ms) = A (ms) + B * [USER DATA (bytes) + 51 (Transparent) or 53 (Address)] + 2 (Margin)

Ex) If air rate is 4800bps & UART baud rate is 9600bps & USER DATA is 50 bytes in transparent mode,
2 (A) + 1.67 (B) * [50 (USER DATA) + 51 (Overhead, Transparent)] + 2 (Margin) = around 172.67ms

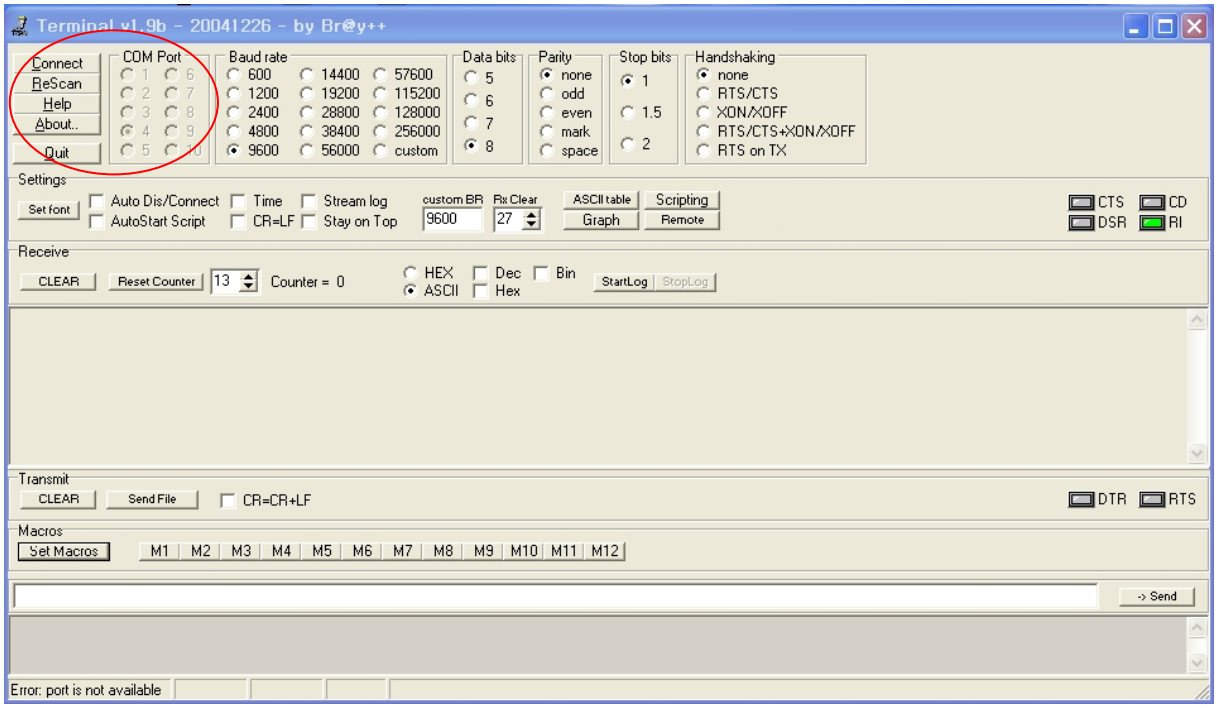
There is 112.67ms of actual overhead latency comparing to 60ms in wire connection in case of

9600bps of baud rate & 4800bps of air rate in order to transmit 50 bytes of data.

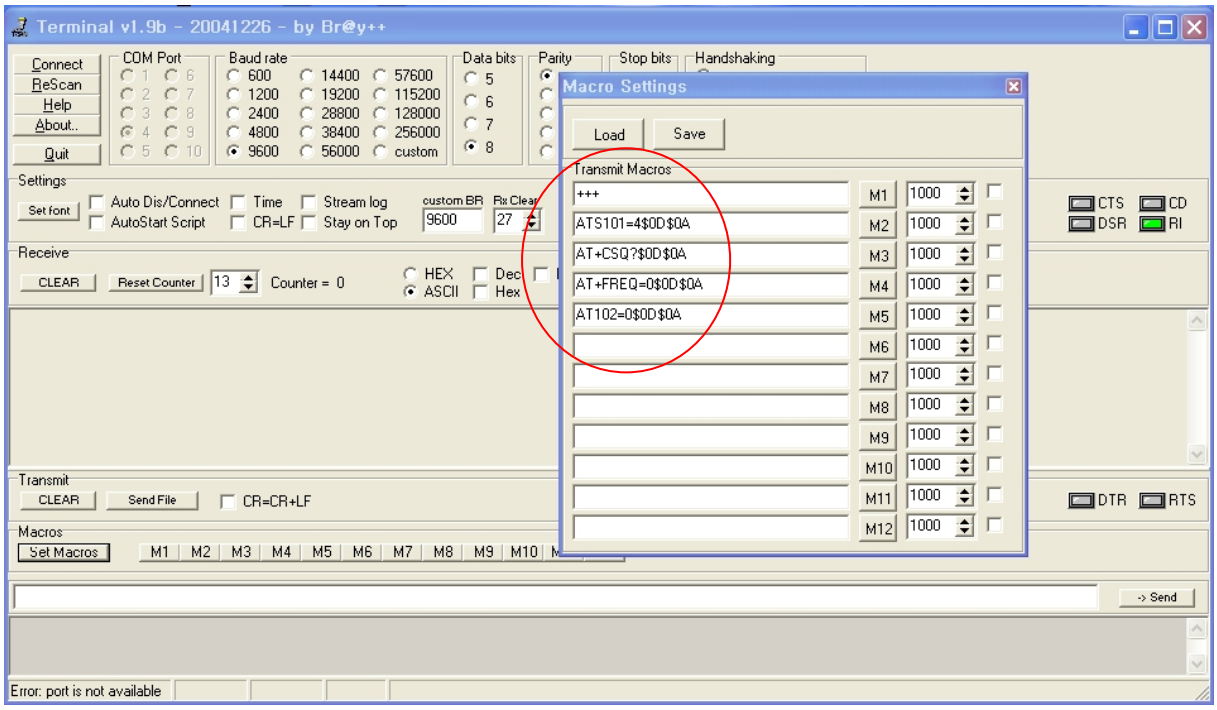
12-6 TERMINAL SETTING

A typical terminal setting

1. Please connect the LinkWiser-S400M to RS-232C in your PC.
2. Please make sure that the mode switch is set to RS-232C before power on. And also please make sure that the input voltage range is within 6VDC to 24VDC.
3. Please execute the terminal program



Please click the "connect" after selection of a proper baud rate.



You can use the "Set Macros" function to make easier to write & read our AT command sets. However, **"$0D$0A"** string should be followed for carriage return in this case.

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